Plant Protection Bulletin 36: 293～299, 1994

Development of *Trichogramma embryophagum* and *T. ostriniae* (Hym.: Trichogrammatidae) at five temperatures and their relative recovery from host eggs

B. H. Chen

Taiwan Agricultural Research Institute, Wu-feng, Taichung, Taiwan, ROC

(Accepted for publication: October 3, 1994)

ABSTRACTS

Chen, B. H. 1994. **Development of *Trichogramma embryophagum* and *T. ostriniae* (Hym.: Trichogrammatidae) at five temperatures and their relative recovery from host eggs.** Plant Prot. Bull. 36:293-299.

Trichogramma embryophagum Hartig and *T. ostriniae* Pang & Chen were compared their development in eggs of *Ostrinia furnacalis* Hübner at five constant temperatures of 14, 18, 22, 26, and 30 ℃ in laboratory. *T. ostriniae* failed to develop at 14 ℃, and both species decreased their developmental period as the temperature increased. *T. embryophagum* performed better in parasitism under 22 ℃, significantly lived longer especially at 18 and 26 ℃, had highly significantly lower female sex ratio at 30 ℃, and predominated over *T. ostriniae* in recovery percentage from host eggs.

(Key words: corn borer, *Trichogramma*, temperature, development, recovery)

INTRODUCTION

The Asiatic corn borer, *Ostrinia furnacalis* Hubner is the most serious insect pest of corn in Taiwan and in South East Asia[2,4,8,9]. It causes damages on leaves, pollen tassels, silks, ears, and stalks of the corn plants. In Taiwan, *Trichogramma ostriniae* Pang & Chen, a

dominated indigenous egg parasitoid, has been extensively released throughout the island since mid-1980's[4]. This egg parasitoid provides good parasitism rate in fall cropping season but unsatisfactory in spring cropping season especially when temperature drops below 20 ℃ (B. H. Chen, unpublished data).

In order to improve parasitism in spring cropping season, about 20 exotic and indigenous *Trichogramma* species maintaining in the laboratory were screened for their suitability to egg masses of *O. furnacalis*. Preliminary results showed that *T. embryophagum* Hartig, an exotic species originating from France, showed the most promising in parasitizing the eggs of Asiatic corn borer (B. H. Chen, unpublished data). *T. embryophagum* has been reported as the dominant species in arboreal habitats[5], and the egg parasitoid of various forest insects[7]. This is the first record indicating *O. furnacalis* eggs as its host in Taiwan.

This study reports the development of *T. embryophagum* and *T. ostriniae* at various constant temperatures in laboratory and their relative recovery percentage from the parasitized egg masses of *O. furnacalis* in the greenhouse, and provides information for determining if this exotic species could complement with the indigenous parasitoid in parasitizing eggs of *O. furnacalis* in Taiwan.

MATERIALS AND METHODS

Egg masses of *O. furnacalis* using in this study were reproduced from the mated female adults of the borers rearing from artificial diet in the laboratory. They were collected daily and stored in refrigerator for at least two days before exposing to egg parasitoid. Culture of the exotic *T. embryophagum* originating from France has been maintained in growth chamber at 25 ± 1 ℃ in Taiwan Agricultural Research Institute since 1991 by using eggs of rice moth, *Corcyra cephalonica* Stainton. Rice moths were placed in oviposition cylinders and eggs being collected daily and glued on paper card of 50 × 30 cm in size. The eggs on the cards were irradiated at 15 cm under UV light of 190 luxes for one hour to prevent hatching before exposing to *Trichogramma*.

Mated *T. embryophagum* females were kept singly in a glass vial sealed with parafilm. Each parasitoid was provided with honey and an egg mass containing about 50 eggs of *O. furnacalis*. This study was conducted in growth chambers at 14, 18, 22, 26, and 30 ℃ with 10 replicates for each temperature. Identical procedures except using *T. ostriniae* instead of *T. embryophagum* were simultaneously conducted as the control. A week later, the parasitized and the unparasitized eggs were recorded separately for each species. The adult longevity, developmental duration, percentage of emergence, progeny sex ratio, and parasitism percentage were recorded and calculated for each species at each temperature. A stereomicroscope was used to dissect the unemerged parasitoids to determine the percentage emergence. Data collected were analyzed by the PROC ANOVA program in the Statistical Analysis System and *t* test was used to separate means at 5% level of significance [10].

Before conducting field release,

searching efficacy of *T. embryophagum* for the egg masses of Asiatic corn borer was compared to that of *T. ostriniae* in the greenhouse. The super sweet corn variety, Honey 236, was planted in acrylic pots of 1/5,000 are in the greenhouse. At the whorl stage, 60 freshly laid egg masses of corn borers were randomly inoculated underneath the whorl leaves among 30 corn plants to simulate natural infestation. Egg card containing about 200 nearly emerging *T. embryophagum* or *T. ostriniae* pupae was simultaneously stapled nearby as the same method recommended to the farmers. Twenty egg masses were randomly sampled per day consecutively for three days beginning from the next day after releasing. Each of the collected egg masses was singly put in a glass vial sealed with parafilm and kept in chamber at 25 ± 1 ℃. The parasitized eggs then turned dark whereas those unparasitized began to hatch, and their respective number was recorded to calculate percentage parasitism for each eggmass collecting at different days. The parasitized egg mass in each vial was allowed to let parasitoid emerge and die. Specimen in each vial were sexed, and those males were mounted and identified by using Olympus BHS microscope to determine the frequency of each species. The number of each species recovered from each sample were tabled and compared by PROC ANOVA in the Statistical Analysis System and *t* test was used to separate means at 5% level of significance[10].

RESULTS AND DISCUSSION

T. ostriniae failed to complete its development at 14 ℃, while *T. embryophagum* did successfully complete development at each constant temperature tested. *T. ostriniae* spent significantly more time to develop at 22 ℃ than did *T. embryophagum* ($P<0.05$), but it developed significantly faster at 18 and 26 ℃ ($P<0.05$). Similar results were reported for *T. exiguum* and *T. pretiosum* which developed slower than each other at 20 and 25 ℃, respectively[6]. These differences may be attributed to species difference in nature. The developmental durations of both species were inversely related to temperature, and ranged from ca. 9.3 days at 30 ℃ to ca. 34.5 days at 14 ℃ (Table 1). This result coincided with previous studies reporting that the development rate of *Trichogramma* and other egg parasitoid species accelerated as the temperature increased[6,11,13].

At 22 ℃, *T. embryophagum* produced the highest 49.5% parasitism on host eggs and was significantly ($P<0.05$) higher than that of 28.2% accomplished by *T. ostriniae* which was observed ovipositing the host eggs but unable to produce parasitism at 14 ℃. No significant differences were found between these two species at the other temperatures tested (Table 1). Similarly, Harrison *et al.* (1985) reported that no significant differences in parasitism were detected between *T. pretiosum* and *T. exiguum* response to or within temperatures. Although the parasitism rates obtained in this experiment were relatively low, however, the results demonstrated that *T. embryophagum* performed better than *T. ostriniae* in producing parasitism when temperature was under 22 ℃, and vice versa as temperature at 26 ℃.

Table 1. Comparison in mean developmental time, percentage of emergence, and percentage of parasitism of *T. embryophagum* and *T. ostriniae* at five temperatures

Temp (℃)	Developmental time(days)		% Emergence		% Parasitism	
	T. embryophagum	*T. ostriniae*	*T. embryophagum*	*T. ostriniae*	*T. embryophagum*	*T. ostriniae*
14	34.5±0.5	–	19.7±7.6	–	23.1±5.4	–
18	25.4±0.3	24.0±0.6*	37.5±10.8	48.0±10.6^{NS}	37.0±6.8	25.3±5.6^{NS}
22	13.3±0.2	14.7±0.3*	66.4±9.8	64.5±11.0^{NS}	49.5±8.4	28.2±5.0*
26	12.4±0.5	11.3±0.2*	30.3±12.1	57.2±9.2*	32.1±2.7	40.3±5.9^{NS}
30	9.3±0.4	10.0±0.4^{NS}	32.8±11.4	31.9±9.2^{NS}	31.6±3.3	31.7±6.9^{NS}

*: $P<0.05$; NS: not significant; *t* test.

Both parasitoid species had the highest emergence rate at 22 ℃, but no significant difference was found between them within tested temperatures except at 26 ℃ on which *T. ostriniae* had significantly higher emergence rate than that of *T. embryophagum* ($P<0.05$) (Table 1). The responses of *T. ostriniae* to temperature at 26 ℃ in emergence and parasitism exactly reflected the field performance of this indigenous parasitoid (B. H. Chen, unpublished data).

The female longevity of *T. ostriniae* decreased as temperature increased. Similar trend was found for *T. embryophagum* from 18 to 30 ℃. *T. embryophagum* lived longer than *T. ostriniae* at all temperatures exposed especially at 18 and 26 ℃ on which the differences were significant ($P<0.05$) (Table 2). The female longevity of both species at five constant temperatures in this study was longer comparing to that of other *Trichogramma* species[6]. The difference may be attributed to different species, and a longer female longevity is in advantage of getting better parasitism.

Both species had more female than male progenies regardless of temperature, and there were no significant differences in female sex ratio between species within temperatures except at 30 ℃ of which *T. embryophagum* was highly significantly lower than that of *T. ostriniae* ($P<0.01$) (Table 2). The female sex ratio of *T. ostriniae* increased as temperature increased, and this is contrary to the previous studies reporting that higher temperature had significant effect on producing more male progenies of the thelytokous *Trichogramma* species[1,3,12]. Because the reproduction mode of *T. ostriniae* is arrhenotokous, whether it is the key factor attributed to the difference or due to effect of temperature on progeny sex ratio is still unknown and needed to be further confirmed.

The recovery percentage of *T. embryophagum* was consistently higher than that of *T. ostriniae* and the difference was highly significant ($P<0.01$) at all three sampling dates. This indicated that the exotic *T. embryophagum* is a better competitor over the indigenous *T. ostriniae* in host searching efficiency. The percentage of egg mass parasitized increased from 30% up to 100% on the third day after releasing the parasitoids (Table 3). This suggested that the two

Table 2. Comparison in female adult longevity and the progeny sex ratio of *T. embryophagum* and *T. ostriniae* at five temperatures

	Longevity (days)		% Sex ratio	
Temp (℃)	*T. embryophagum*	*T. ostriniae*	*T. embryophagum*	*T. ostriniae*
14	13.5±1.9	12.5±0.6^{NS}	0.73±0.14	–
18	16.2±1.2	11.7±1.5*	0.69±0.12	0.80±0.13^{NS}
22	11.7±0.5	10.1±0.9^{NS}	0.85±0.04	0.88±0.03^{NS}
26	9.7±0.4	6.5±0.2**	0.89±0.04	0.90±0.03^{NS}
30	5.1±0.3	4.4±0.3^{NS}	0.42±0.15	0.91±0.03**

*: $P<0.05$; **: $P<0.01$; NS: not significant; *t* test.

Table 3. Relative recovery percentage of two *Trichogramma* species from the parasitized egg masses of *O. furnacalis* in the greenhouse

Sampling	% egg mass	Recovery percentage of	
date	parasitized	*T. embryophagum*	*T. ostriniae*
12/24/92	30.0	70.8**	29.2
12/25/92	94.8	73.0**	27.0
12/26/92	100.0	71.9**	28.1

**: $p<0.01$, *t* test.

parasitoid species could complement to each other without mutual interference in parasitizing host egg masses. Thus, species replacement of the domestic *T. ostriniae* is unlikely to be happened after releasing the exotic *T. embryophagum* in the fields.

Overall, *T. embryophagum* was superior to *T. ostriniae* in low temperature adaptation, having higher parasitism rate and female longevity at temperature under 22 ℃. On the contrary, the indigenous species was found unable to develop at 14 ℃. However, during early spring cropping season, temperatures of 22 ℃ and below are common in Taiwan. Results of this study therefore provided evidence why *T. ostriniae* was unable to contribute satisfactory control during that cropping season. *T. embryophagum* also predominated over *T. ostriniae* in parasitizing host eggs when they were simultaneously released. Thus, the exotic egg parasitoid demonstrated its complementary potential in parasitizing the Asiatic corn borer in the spring cropping season.

ACKNOWLEDGEMENTS

Thanks are due to T. C. Wu and S. Y. Liu for technical assistance. This project was financially supported by Corn Foundation (82-corn-3) from Council of Agriculture, Taipei, Taiwan, ROC.

LITERATURE CITED

1. Bowen, W. R., and Stern, V. M. 1966.

Effect of temperature on the production of males and sexual mosaics in a uniparental race of *Trichogramma semifumatum* (Hymenoptera: Trichogrammatidae). Ann. Entomol. Soc. Am. 59:823-834.

2. Camarao, G. C. 1976. Population dynamics of the corn borer, *Ostrinia furnacalis* Guenee, I. Life cycle, behavior and generation cycles. Philipp. Ent. 3:179-200.
3. Chen, B. H., Kfir, R., and Chen, C. N. 1992. The thelytokous *Trichogramma chilonis* in Taiwan. Entomol. Exp. Appl. 65:187-194.
4. Chiu, S. C., and Chien, C. C. 1985. Biological control of corn borers. Plant Prot. Bull. 27:299-316 (in Chinese with English summary).
5. Flanders, S. E. 1937. Notes on the life history and an atomy of *Trichogramma*. Ann. Entomol. Soc. Am. 30:304-308.
6. Harrison, W. W., King, E. G., and Ouzts, J. D. 1985. Development of *Trichogramma exiguum* and *T. pretiosum* at five temperature regimes. Environ. Entomol. 14:118-121.
7. Klomp, H., and Teerink, B. J. 1978. The elimination of supernumerary larvae of the gregarious egg-parasitoid *Trichogramma embryophagum* (Hym.: Trichogrammatidae) in eggs of the host *Ephestia kuehniella* (Lep.: Pyralidae). Entomophaga 23:153-159.
8. Lit, M. C., Adalla, C. B., and Lantin, M. M. 1989. Host plant resistance to the Asiatic corn borer, *Ostrinia furnacalis*, in the Philippines, pp. 277-280. In CIMMYT (ed.) Toward Insect Resistant Maize for the Third World: Proceedings of the International Symposium on Methodologies for Developing Host Plant Resistance to Maize Insects. Mexico, D. F. : CIMMYT.
9. Morallo-Rejesus, B. 1985. Research advances and needs in the control of Asiatic corn borer, *Ostrinia furnacalis* (Guenee), in the Philippines. Philipp. Ent. 6:406-426.
10. SAS Institute. 1982. User's Guide: Statistics. SAS Inst. Inc., Cary, NC.
11. Stern, V. M., and Bowen, W. 1962. Ecological studies of *Trichogramma semifumatum*, with notes on *Apanteles medicaginis* and their suppression of *Colias eurytheme* in Southern California. Ann. Entomol. Soc. Am. 56:358-372.
12. Stouthamer, R., and Luck, R. F. 1988. Microorganisms implicated as a cause of thelytokous parthenogenesis in *Trichogramma* spp. (Hymenoptera: Trichogrammatidae), p. 256. In Proceedings of the XVIII International Congress of Entomology, Vancouver, B. C., Canada.
13. Tracy, J. L., and Nechols, J. R. 1987. Comparisons between the squash bug egg parasitoids *Ooencyrtus anasae* and *O.* sp. (Hymenoptera: Encyrtidae): Development, survival, and sex ratio in relation to temperature. Environ. Entomol. 16:1324-1329.

摘　要

陳炳輝　1994　兩種赤眼卵寄生蜂在五種定溫之發育與自寄主卵之相對回收率　植保會刊　36:293-299.（臺灣省農業試驗所　應用動物系）

室內測定二種赤眼卵寄生蜂，*Trichogramma embryophagum*與*T. ostriniae* 在14, 18, 22, 26及30℃等五種定溫下，在亞洲玉米螟卵內之發育。結果顯示*T. ostriniae*在14℃時不能完成發育，且兩種卵寄生蜂之發育期隨溫度之升高而縮短。*T. embryophagum*在溫度低於22℃時，對玉米螟卵之寄生率優於*T. ostriniae*；其雌蜂壽命較本地種爲長，尤以在18與26℃時二者呈顯著差異；該蜂在30℃時之雌性比極明顯較*T. ostriniae*爲低，但其自寄主卵之回收率，則比此本地種爲優。

（關鍵詞：玉米螟、赤眼卵寄生蜂、溫度、發育、回收）